Examining the Impact of Collaborative Homework on Student Performance in an Engineering Materials Course

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Abstract

Previous studies have shown the usefulness of interactive collaborative methods for building engagement and improving comprehension of course material. While the authors regularly utilized out-of-class group projects and in-class group exercises for freshmen and seniors, the collaborative approach was extended to homework assignments for the first time. The results presented include the results of student surveys as well as course grades from the piloted collaborative homework semester compared with previous semesters with standard individual homework. This paper represents the initial findings and the plans for continued research.

Keywords

homework, collaboration, teamwork, active learning, scholarship of teaching and learning

Background

The goal of teaching is to produce understanding, not merely the ability to memorize or mimic but to understand and apply information to new problems. As neuroscientists and cognitive scientists better understand the changes in neural pathways that accompany learning, education researchers are developing techniques to increase the impact of classroom experiences. Of particular relevance to the current work, learning is enhanced when students elaborate ideas through talk.[1] This knowledge has given rise to the commonly-used think-pair-share exercise where students talk through and solve a problem together. A handful of researchers have gone beyond this and implemented "cooperative out-of-class exercises"[2] in engineering courses at institutions such as North Carolina State University[1], University of Central Florida[3], The Pennsylvania State University[4], and Lamar University[5]. Given the success at those universities, in addition to the knowledge that the best way to learn something is to explain it to someone else, the authors chose to apply this collaborative methodology to weekly homework assignments.

Process

While the authors regularly utilized out-of-class group projects and in-class group exercises for freshmen and seniors, the collaborative approach was extended to weekly homework assignments for the first time. This study was conducted in three sections of a junior level engineering materials course within the Department of Mechanical Engineering and taught by two different faculty. This particular course was selected because much of the material built on concepts that the students had last used in coursework two years prior. Additionally, as this course emphasized concepts but not calculations, it lent itself to group discussion and analysis as a means for bolstering comprehension.

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During the first day of class during the Fall 2019 semester, students were introduced to the framework of the group homework plan. Students were given 5 minutes to create groups of 3 to 4 students. Students were told they may be given the opportunity to remove a student for poor performance or to switch groups part of the way through the semester.

For each assignment, these groups worked collaboratively on each homework assignment, verifying that all members of the group understood and could independently execute all problems. Although the problems were completed cooperatively, each student submitted his/her own work for each homework. One student's work was graded for each problem, but the entire group received that student's score for that problem. To further encourage students to fully understand each of the homework problems, students were told that each test would contain at least one question taken directly from the homework.

Also, to promote discussion among the student about the course concepts, homework solutions were not posted but instead, only the graded student's paper indicated areas for focus and improvement, with comments written directly onto only the selected student's submission. Students were encouraged to discuss the hand-written feedback with their group to analyze gaps in their approach and understanding.

Measurement

To assess the impact of collaborative homework, two different methods were chosen. First, the impact on academic performance was assessed through evaluation of the final course grades. As the same two faculty taught the course the previous year and as one of the faculty had taught it for two years before that, a year-to-year comparison was reasonable. Second, a 19-question survey on student perception was administered (n~80) at the midpoint of the semester and then again at the conclusion of the course. The survey, using the Likert scale (1 = Strongly Disagree to 5 = Strongly Agree) for response, centered around 3 main themes: approach to group formation, the process used to complete the homework as a group, and perceptions on the impact of collaborative homework.

Results

During the pilot semester, the percentage of students who earned an A or a B in the course was 81% (Figure 1), the highest level recorded in the history of the course at the institution. While it is not possible at this time to determine if collaborative homework was definitively the major contributing factor to this academic performance, almost all other aspects of instruction were held constant for the Fall 2019 semester; as such, these results suggests that collaborative homework had a positive impact on learning.

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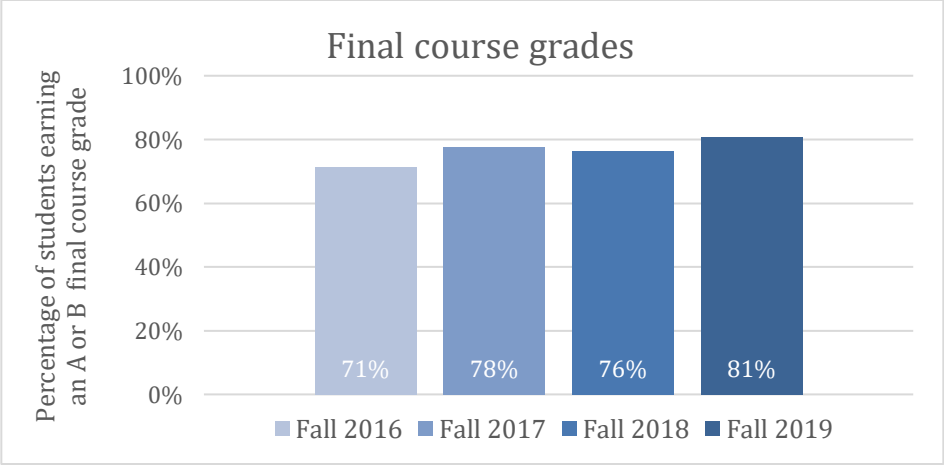

Figure 1: The percentage of students who received a final course grade of an A or a B.

Survey results indicated that most students were excited about the prospect of collaborative homework: at midterm 54% of students responded that they agreed or strongly agreed that they were excited for collaborative homework. This percentage increased to 69% by the end of the semester. Table 1 shows some key questions asked on the midterm and end of term surveys and the average response of the students.

Table 1: Summary of Student Survey Questions and Responses

Statement	**Mean Response Midterm** 1 = Strongly Disagree to 5 = Strongly Agree	**Mean Response End of Term** 1 = Strongly Disagree to 5 = Strongly Agree
When I first heard about the prospect of group homework I was excited.	3.45	3.68
When forming my group I just teamed up with whoever was nearby and not already in a group.	2.82	2.99
In my group, we work together from start to finish on each of the problems.	2.68	2.55
I don't work with the group, I just turn in my own solutions.	1.45	2.00
I think I have learned more through group homework than I would have on my own.	3.36	3.49
I feel it is fair that the whole group shares the same homework score.	3.59	3.49
If given the opportunity, I would like to reform my group.	2.03	2.80
I would like to continue with group homework for the remainder of this course.	4.01	4.09

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In an effort to assess trends in student survey responses, a simple correlation coefficient calculation was performed. The correlation coefficient was calculated in Microsoft Excel using the following equation,

$$C = \frac{\sum(x - \bar{x})(y - \bar{y})}{\sqrt{\sum(x - \bar{x})^2 \sum(y - \bar{y})^2}}$$

where x and y represent an individual student's response to survey statements and $\bar{x}$ and $\bar{y}$ represent the mean response to the respective statement. This is Pearson's correlation and it was chosen because it is one of the most commonly used correlation coefficients in linear regression analysis. The correlation coefficient ranged from +1 to -1, with positive numbers indicating a positive correlation and negative numbers indicating a negative correlation. Numbers closer to +1 and -1 represented a strong correlation and values closer to 0 represented weak, or little correlation.

No strong correlation (max +/-0.45) was found between the manner in which a group was formed and perceptions on the impact of collaborative homework. Approximately half of the students indicated that during group formation they considered who would help them learn the most. Only a third of students formed their group based on proximity and availability.

Students who were excited about collaborative homework were more likely to want to continue collaborative homework as indicated by a strong positive correlation value of 0.70 at midterm. This correlation weakened to 0.51 by the end of the semester even though there was an increase in the number of students who reported being excited about collaborative homework.

A majority of students (74%) thought they learned the same or more (responded 3, 4 or 5) through collaborative homework than if they completed the homework on their own. There was a moderately positive correlation of 0.60 between those who thought they learned more and those who felt it was fair that the entire group received the same grade.

Students who thought they learned more through collaborative homework than if they would have on their own were, unsurprisingly, most likely to want to continue collaborative homework, with a maximum observed positive correlation of 0.76.

Being able to trust their group members was important to students. A negative correlation of -0.68 was found between whether a student trusted their group members and their desire to reform their group. Specifically, as trust in teammates increased the desire to reform their team decreased. More information is needed to determine if the perceived problem was limited to a single group member or if multiple group members were deemed untrustworthy.

Comments

As mentioned above, not all students appreciated group homework. Non-contributing teammates was a major frustration for some groups. One student wrote "I would be more open to group homework if there was a way to kick someone off the team." In addition, commuter students,

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who do not live on campus like the rest of the student population at our residential university, found it difficult to schedule time for collaboration and were vocal in their frustration.

Next steps

Unfortunately, this work was not able to be continued in the Fall 2020 semester due to COVID greatly altering the mode of instruction. As we prepare for the Fall 2021 semester, the authors intend to implement this collaborative homework methodology with some modifications. One area for improvement is the group formation methodology. In the future the professor should either assign specific groups or at least suggest some criteria that the students use in forming their groups, for example consider the reliability of their classmate. Additionally, periodic regrouping during the semester is recommended to lessen the frustration of a non-contributing group member.

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